

Atmospheric neutrinos studies in SNO

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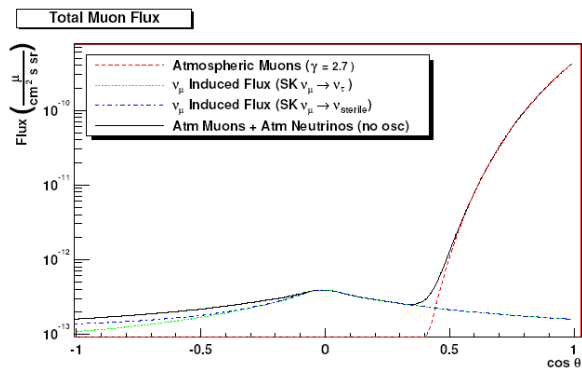


FIG. 1: Simulated zenith dependence of the flux for both down-going cosmic muons and neutrino induced muons as expected at SNO. The effect of various oscillation scenarios is visible below the horizon.

High energy muons and neutrinos are produced permanently by the interaction of primary cosmic rays in the Earth's upper atmosphere.

At the depth of over 6 km water equivalent, SNO is the deepest underground laboratory currently in operation.

The only particles that can penetrate down to the SNO detector are neutrinos and muons. The atmospheric neutrinos can interact with the rock and in turn produce muons that can be detected by SNO. The rate of detection of such events is a fraction of the downward muon rate but SNO's angular resolution is sufficient to make a clean separation up to an angle $\cos\theta < 0.4$ above the horizon.

SNO's unique niche allows it to make important model independent checks of atmospheric neutrino oscillations. Assuming $\nu_\mu \rightarrow \nu_\tau$ oscillation parameters $(\Delta m^2, \sin^2 2\theta) = (2.5 \times 10^{-3}, 1)$ which existing atmospheric neutrino data point to Fukuda et al. [1], neutrinos coming from above the horizon do not oscillate due to a shorter path length through Earth, whereas the lower energy half of those coming up from below the horizon do ($E \lesssim 100$ GeV).

SNO's contribution is to detect both oscillated and unoscillated neutrino-induced through going muons at the same time. Those coming from above the horizontal are unhampered by oscillation effects and provide a good test of flux models, only loosely constrained to date. These muons thus set a model-independent normalization for the analysis of a possible oscillation signal of events from below the horizon as illustrated on Figure 1.

The analysis is based on a 800-days data set and uses

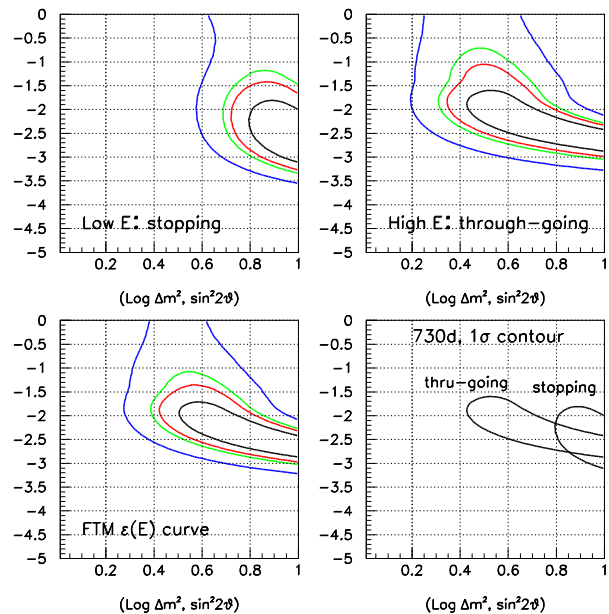


FIG. 2: Projected sensitivity contours for a $\nu_\mu \rightarrow \nu_\tau$ oscillation at SNO with $(\Delta m^2, \sin^2 2\theta) = (2.5 \times 10^{-3}, 1)$ with 730 live days of data. The curves represent confidence levels of 68%, 90%, 95%, and 99% for stopping and through-going muons. The performance achieved by one of the reconstruction algorithm is also shown. Statistical study only.

both the heavy and light water volumes in SNO as target, for a total of approximately 2.7 ktonnes. Two types of events are used separately to provide the best constrain in the oscillation parameters space. Muons traversing the detector provide a broad scan of the high energy part of the neutrino spectrum. There is an equal number of muons stopping inside the detector up to energies of 3–4 GeV. The effort is focused on achieving an unbiased reconstruction of the muon direction. Figure 2 shows the projected sensitivity on the measurement of the atmospheric neutrino parameters in SNO. This extraction is statistical only and does not include instrumental effects or reconstruction biases.

Although SNO is of modest size compared to other Cherenkov detectors, the perspective of performing virtually model-independent measurements on atmospheric neutrinos makes it particularly competitive.

[1] Y. Fukuda et al., Phys. Rev. Lett. **82**, 2644 (2002).